AMENDMENT NO. 1 MARCH 2022

TO

IS 1893 (PART 2) : 2014 CRITERIA FOR EARTHQUAKE RESISTANT DESIGN OF STRUCTURES

PART 2 LIQUID RETAINING TANKS

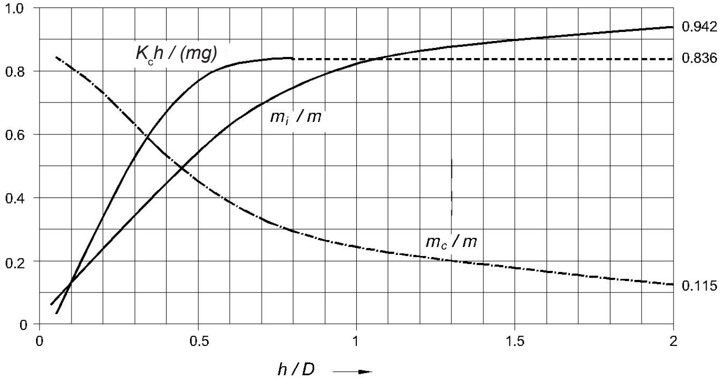
(Fifth Revision)

(*Page* 1, *clause* **3.0**, *line* 15) — Substitute '$\overline{h}$' *for* '*h*'.

(*Page* 3, *clause* **4.2.1.2**) — Insert the following at the end:

'Expressions for these parameters are given in Annex A'.

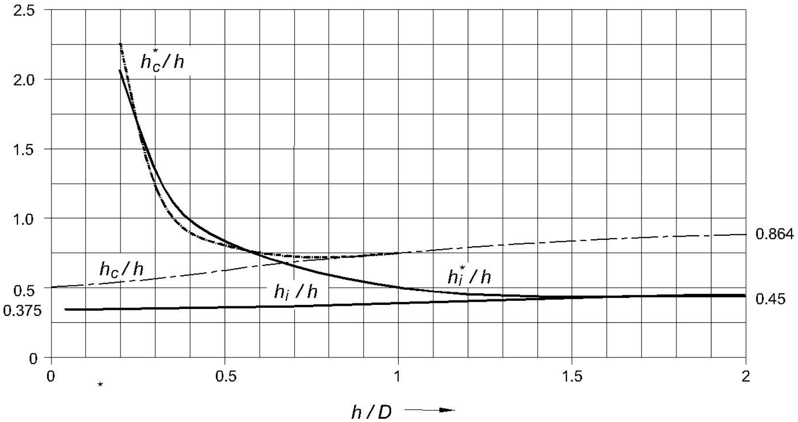
[*Page* 3, *Fig.* 2(a) and 2(b)] — Substitute the following figures for the existing:



2(a) IMPULSIVE AND CONVECTIVE MASS AND CONVECTIVE SPRING STIFFNESS

Price Group 4

[*Page* 3, Fig 2 (b)] — *Substitute the following for the existing*:



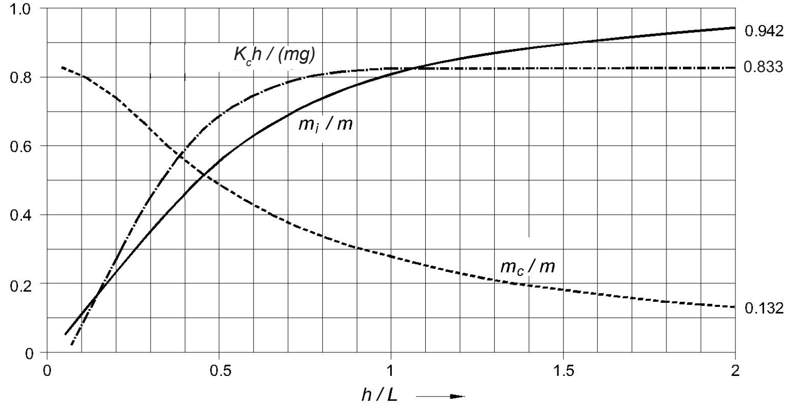
2(b) Heights of Impulsive and Convective Masses

Fig. 2 Parameters of the Spring Mass Model for Circular Tank

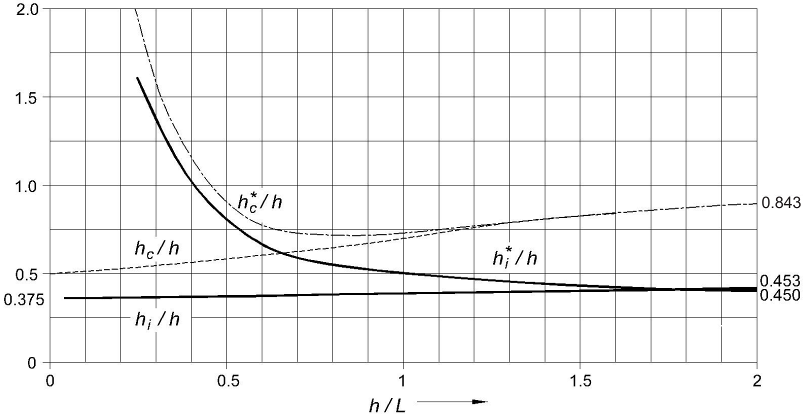
(*Page* 3, *clause* **4.2.3**, line 5) — Insert ',' after 'h_c'.

(*Page* 4, *clause* **4.3.1.2**, line 7) — Substitute '$\bar{h}$' *for* 'h'.

[*Page* 4, *Fig.* 3(a) and 3(b)] — Substitute the following figures for the existing:



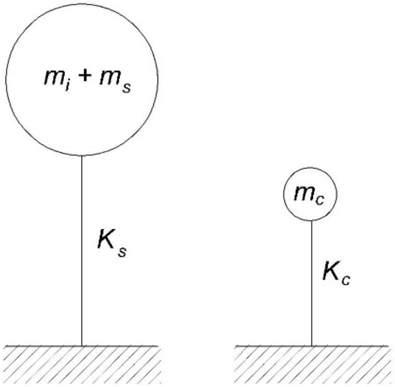
3(a) IMPULSIVE AND CONVECTIVE MASS AND CONVECTIVE SPRING STIFFNESS



3(b) HEIGHTS OF IMPULSIVE AND CONVECTIVE MASSES

FIG. 3 PARAMETERS OF THE SPRING MASS MODEL FOR RECTANGULAR TANK

[*Page* 5, *Fig.* 4(d)] — Substitute the following figure for the existing:



4(d) EQUIVALENT UNCOUPLED SYSTEM TANK

(*Page* 5, *Fig.* 5) — Substitute the following figure for the existing:

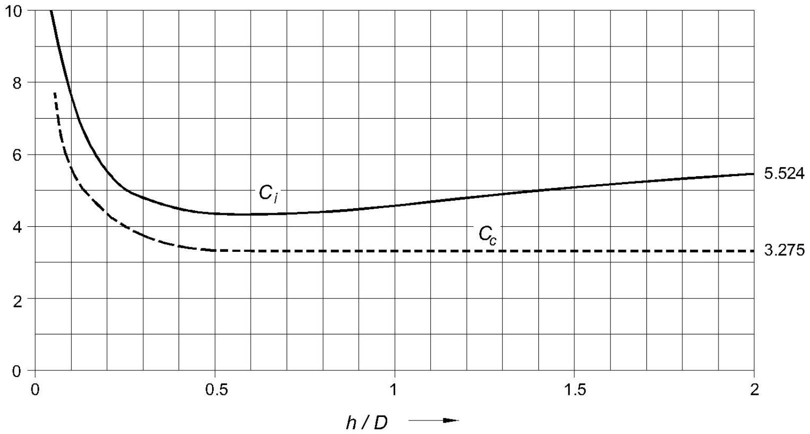


FIG. 5 COEFFICIENT OF IMPULSIVE (C_i) AND CONVECTIVE (C_c) MODE TIME PERIOD FOR CIRCULAR TANK

(*Page* 6, *clause* **4.3.2.1**, *equation for* T_1) — Substitute 'T_c' *for* 'T_1'.

[*Page* 6, *clause* **4.3.2.2**(a), *equation for* T_c] — Substitute 'g' *for* 'ρ'.

[*Page* 6, *clause* **4.3.2.2**(b), *line* 4] — Substitute 'g' *for* 'ρ'.

(*Page* 7, *Table* 2) — Substitute the following table for the existing:

Table 2 Suggested Values of '*R*' for Elevated Tanks

(*Clause* 4.5)

Sl No. (1)	Type of Elevated Tank (2)	Value of '*R*' (3)
i)	Tank supported on masonry shaft (*Not permitted in zones III, IV and V*):	
	a) Shaft reinforced with horizontal bands	1.5
	b) Shaft reinforced with horizontal bands and vertical bars	2.0
ii)	Tank supported on RCC shaft with :	
	a) Reinforcement in two curtains (in both directions)	2.5
	b) Reinforcement in two curtains (in both directions) and with stiffened openings and bracings	3.0
iii)	Tank supported on RCC framed staging$^{1)}$	
	a) Ordinary moment resisting frame (OMRF) type$^{2)}$	2.0
	b) Special moment resisting frame (SMRF) conforming to ductility requirement of IS 13920	3.0
iv)	Tank supported on steel framed staging$^{1)}$	
	a) Special moment resisting frame (SMRF) without diagonal brace	2.5
	b) Special moment resisting frame (SMRF) with diagonal brace	3.0

$^{1)}$ These *R* values are meant for liquid retaining tanks on frame type staging which are inverted pendulum type structures. These *R* values shall not be misunderstood for those given in other parts of IS 1893 for buildings and industrial frames.

$^{2)}$ OMRF is permitted only in Zone II for tanks up to capacity 50 m^3 and staging height of 12 m.

NOTE — P-Δ effect should be considered in the design of staging.

(*Page* 7, *Table* 3) — Substitute the following table for the existing:

Table 3 Suggested Values of '*R*' for Ground Supported Tanks

(*Clause* 4.5)

Sl No. (1)	Type of Ground Supported Tank (2)	Value of '*R*' (3)
i)	Masonry tank:	
	a) Masonry wall reinforced with horizontal bands *(Not permitted in zone IV and V)*	1.5
	b) Masonry wall reinforced with horizontal bands and vertical bars at corners and jams of openings	2.0
ii)	RCC or prestressed tank:	
	a) Fixed or hinged/pinned base tank (*see* Fig. 6a, 6b, 6c)	2.0
	b) Anchored flexible base tank (*see* Fig. 6d)	2.5
	c) Unanchored contained or uncontained tank (*see* Fig. 6e, 6f)	1.5
iii)	Steel tank:	
	a) Unanchored base	1.5
	b) Anchored base	2.5
iv)	Underground RC and steel tank (*see* Note)	3.0

NOTE — For partially buried tanks, value of *R* can be interpolated between ground supported and underground tanks based on depth of embedment.

(*Page* 8, *clause* **4.6.3**) — Insert the following clause at the end:

'**4.6.4** — For design, the horizontal impulsive coefficient $(A_h)_i$ shall not be less than that given in table below.'

Seismic zone	*Ratio*	*In percent*
II	0.015	1.5
III	0.020	2.0
IV	0.030	3.0
V	0.045	4.5

(*Page* 6, *Fig.* 7) — Substitute the following figure for the existing:

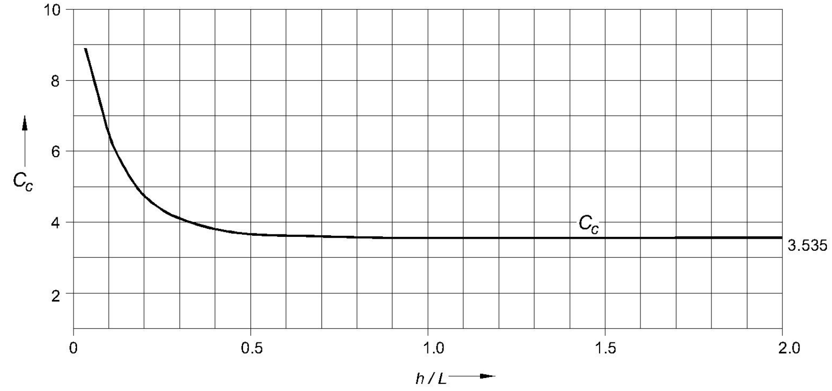


FIG. 7 COEFFICIENT OF CONVECTIVE MODE NATURAL PERIOD (C_c) FOR RECTANGULAR TANK

(*Page* 8, *clause* **4.7.2**) — In the expression of ‘M^*_c’, substitute ‘h^*_c’ *for* ‘h_{cg}’.

[*Page* 9, *clause* **4.9.1**(a), *equation for* P_{ib}] — Substitute ‘p_{ib}’ *for* ‘P_{ib}’ and ‘$(A_h)_i$’ *for* ‘$(A_h)_l$’.

[*Page* 9, *Fig.* 8(a)] — Substitute “*l*’ ” *for* ‘1`’.

[*Page* 10, *clause* **4.9.1**(b)] — Substitute ‘p_{ib}’ *for* ‘P_{ib}’.

[*Page* 10, *clause* **4.9.1**(b), *equation for* $Q_{ib}(x)$] — Substitute the following for the existing:

$$Q_{ib}\left(x\right) = 0.866 \frac{\sinh\left(1.732\dfrac{x}{h}\right)}{\cosh\left(0.866\dfrac{L}{h}\right)}$$

[*Page* 10, *clause* **4.9.2**(a), *equation for* p_{cw}] — Substitute the following for the existing:

$$`p_{cw} = Q_{cw}(y)\,(A_h)_c\,\rho\,g\,D\left(1-\frac{1}{3}\cos^2\phi\right)\cos\phi\,'$$

[*Page* 10, *clause* **4.9.2**(a), *equation for* $Q_{cb}(x)$] — Substitute '3.674' *for* '0.3674' in the expression for $Q_{cb}(x)$.

[*Page* 10, *clause* **4.9.2**(a), *equation for* P_{cb}] — Substitute 'p_{cb}' *for* 'P_{cb}'.

[*Page* 10, *clause* **4.9.2**(b), *equation for* P_{cb}] — Substitute 'p_{cb}' *for* 'P_{cb}'.

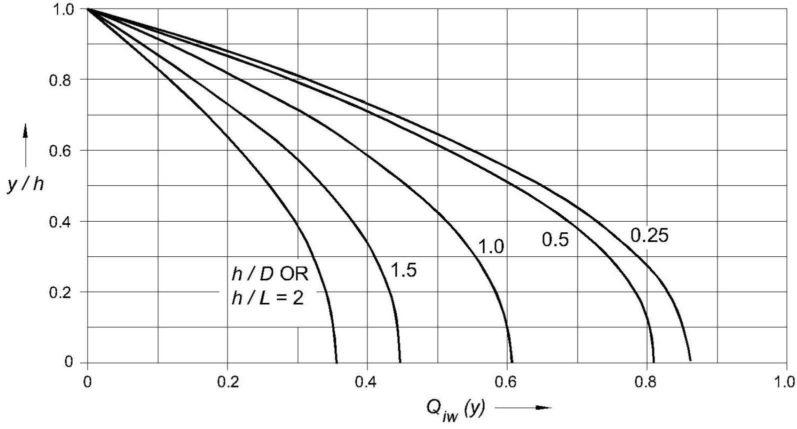
[*Page* 10, *clause* **4.9.2**(b), *equation for* $Q_{cb}(x)$] — Substitute '1.25' *for* '1.125'.

(*Page* 10, *clause* **4.9.5**) — Substitute 'p_{ww}' *for* 'P_{ww}'.

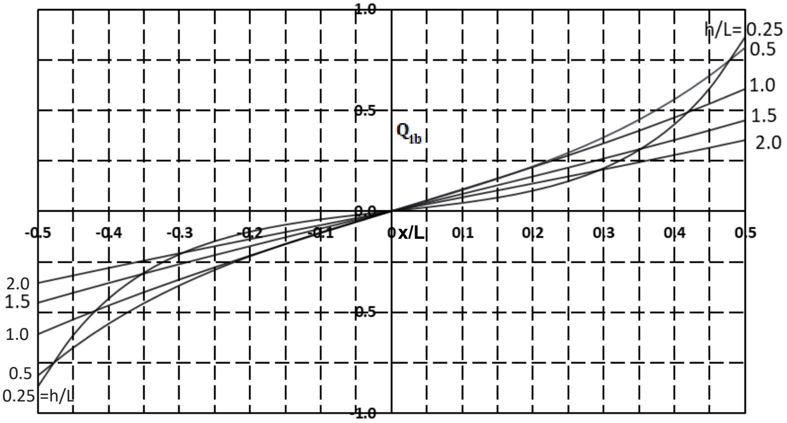
(*Page* 10, *clause* **4.10**) — Substitute the following for the description of (S_a/g) in place of the existing:

'(S_a/g) = Average response acceleration coefficient to be taken as 2.5'.

[*Page* 11, *Fig.* 9(a) and 9(b)] — Substitute the following figures for the existing:



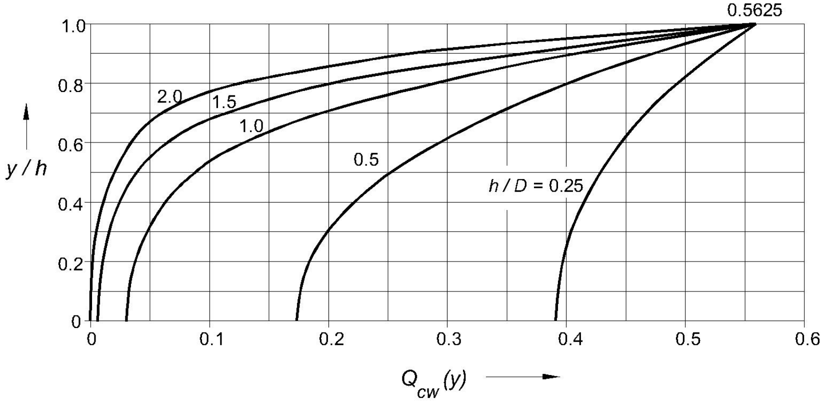
9(a) On Wall of Circular and Rectangular Tanks



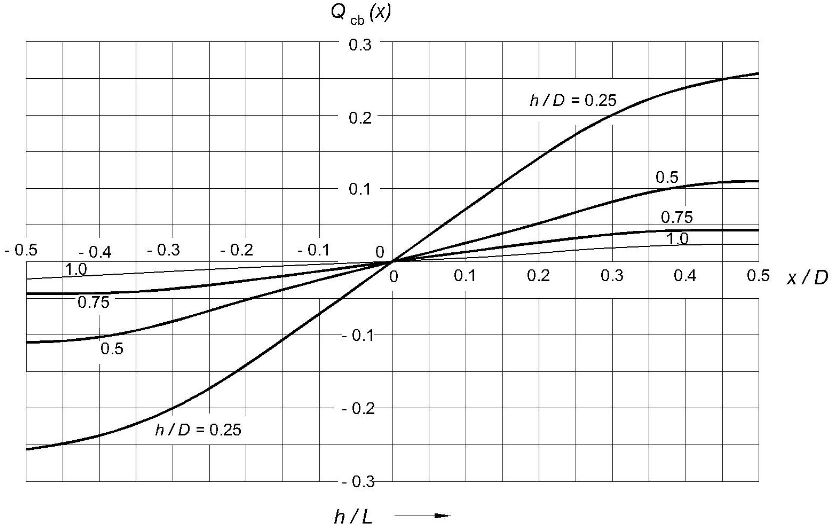
9(b) ON BASE OF RECTANGULAR TANK

FIG. 9 IMPULSIVE PRESSURE COEFFICIENT

[*Page* 12, *Fig.* 10(a) and 10(b)] — Substitute the following figures for the existing:



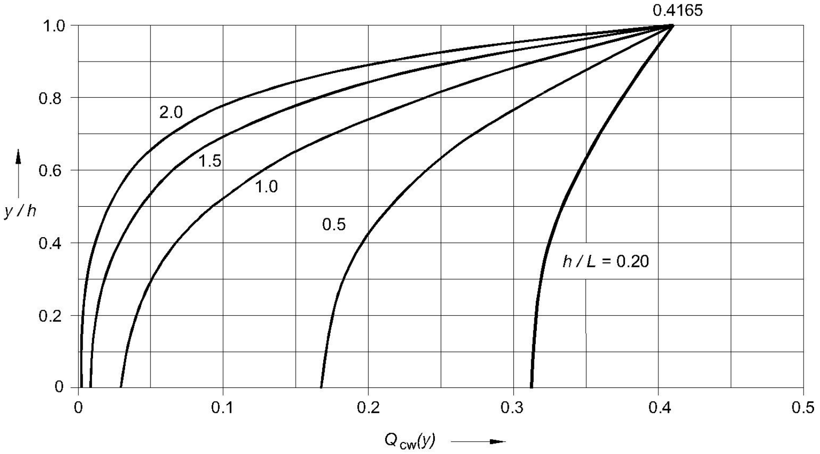
10(a) ON WALL



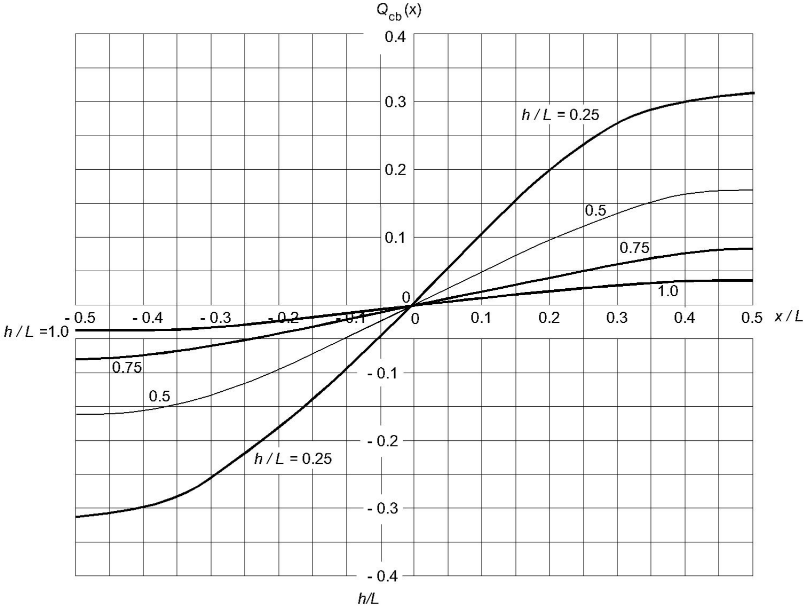
10(b) ON BASE

FIG. 10 CONVECTIVE PRESSURE COEFFICIENT FOR CIRCULAR TANK

[*Page* 13, *Fig.* 11(a) and 11(b)] — Substitute the following figures for the existing:



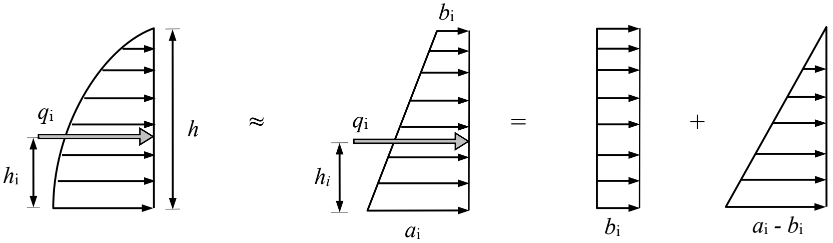
11(a) ON WALL



11(b) On Base

Fig. 11 Convective Pressure Coefficient For Rectangular Tank

[*Page* 14, *Fig.* 12(b)] — Substitute the following figure for the existing:



ACTUAL IMPULSIVE PRESSURE DITRIBUTION

EQUIVALENT PRESSURE DISTRIBUTION

UNIFORM

LINEAR

12(b) Equivalent Linear Distribution Along Wall Height For Impulsive Pressure

(*Page* 16, *clause* **6.5**) — Insert the following at the end:

‘6.6 Cantilever Projections

6.6.1 *Vertical Projections*

Towers, tanks, parapets and other vertical cantilever projections attached to structures and projecting above the roof, shall be designed for five times the design horizontal seismic coefficient for impulsive mode $(A_{\mathrm{h}})_{\mathrm{i}}$ as calculated in **4.5**.

6.6.2 *Horizontal Projections*

All horizontal projections like walkways and balconies shall be designed for five times the design vertical seismic coefficient for impulsive mode $(A_{\mathrm{v}})_{\mathrm{i}}$ as calculated in **4.10.1.**

6.6.3 The increased design forces specified in **6.6.1** and **6.6.2** are only for designing the projecting parts and their connections with the main structures. For the design of the main structure, such increase shall not be considered.’

(*Page* 18, *clause* **8.5**) — Insert the following Annex at the end:

ANNEX A

(*Clause* 4.2.1.2)

EXPRESSIONS FOR PARAMETERS OF SPRING MASS MODEL

For Circular Tank	For Rectangular Tank
$\frac{m_{\mathrm{i}}}{m} = \frac{\tanh\left(0.866\frac{D}{h}\right)}{0.866\frac{D}{h}}$	$\frac{m_{\mathrm{i}}}{m} = \frac{\tanh\left(0.866\frac{L}{h}\right)}{0.866\frac{L}{h}}$
$\frac{h_{\mathrm{i}}}{h} = 0.375$ for $h/D \le 0.75$	$\frac{h_{\mathrm{i}}}{h} = 0.375$ for $h/L \le 0.75$

For Circular Tank	For Rectangular Tank
$= 0.5 - \frac{0.09375}{h/D}$ for $h/D > 0.75$	$= 0.5 - \frac{0.09375}{h/L}$ for $h/L > 0.75$
$\frac{h_\mathrm{i}^*}{h} = \frac{0.866\frac{D}{h}}{2\tanh\left(0.866\frac{D}{h}\right)} - 0.125$ for $h/D \leq 1.33$	$\frac{h_\mathrm{i}^*}{h} = \frac{0.866\frac{L}{h}}{2\tanh\left(0.866\frac{L}{h}\right)} - 0.125$ for $h/L \leq 1.33$
$= 0.45$ for $h/D > 1.33$	$= 0.45$ for $h/L > 1.33$
$\frac{m_\mathrm{c}}{m} = 0.23\frac{\tanh\left(3.68\frac{h}{D}\right)}{\frac{h}{D}}$	$\frac{m_\mathrm{c}}{m} = 0.264\frac{\tanh\left(3.16\frac{h}{L}\right)}{\frac{h}{L}}$
$\frac{h_\mathrm{c}}{h} = 1 - \frac{\cosh\left(3.68\frac{h}{D}\right) - 1.0}{3.68\frac{h}{D}\sinh\left(3.68\frac{h}{D}\right)}$	$\frac{h_\mathrm{c}}{h} = 1 - \frac{\cosh\left(3.16\frac{h}{L}\right) - 1.0}{3.16\frac{h}{L}\sinh\left(3.16\frac{h}{L}\right)}$
$\frac{h_\mathrm{c}^*}{h} = 1 - \frac{\cosh\left(3.68\frac{h}{D}\right) - 2.01}{3.68\frac{h}{D}\sinh\left(3.68\frac{h}{D}\right)}$	$\frac{h_\mathrm{c}^*}{h} = 1 - \frac{\cosh\left(3.16\frac{h}{L}\right) - 2.01}{3.16\frac{h}{L}\sinh\left(3.16\frac{h}{L}\right)}$

For Circular Tank	For Rectangular Tank
$K_c = 0.836\frac{mg}{h}\tanh^2\left(3.68\frac{h}{D}\right)$	$K_c = 0.833\frac{mg}{h}\tanh^2\left(3.16\frac{h}{L}\right)$
$C_i = \left(\frac{1}{\sqrt{h/D}\left(0.46-0.3h/D+0.067\left(h/D\right)^2\right)}\right)$	—
$C_c = \frac{2\pi}{\sqrt{3.68\tanh\left(3.68(h/D)\right)}}$	$C_c = \frac{2\pi}{\sqrt{3.16\tanh\left(3.16(h/L)\right)}}$

(CED 39)

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